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***Vertical Linkages and Multinational Plant Size***

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# Vertical linkages and multinational plant size

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## Abstract

This paper deals with the location of input supply in a two country spatial economy. A duopoly supplies intermediate goods to a perfectly competitive consumer good industry that operates with a quadratic production function inspired in PENG, THISSE and WANG (2006). Since the consumer good is non-tradable, the downstream industry locates in both countries and can be viewed as made by a set of multinational firms. On the one hand joint location of the upstream firms is caused by a localization economy and by the intensity of the demand addressed to the industry. On the other hand production and transport costs of the input lead to dispersed locations by the upstream firms. If the input suppliers agglomerate, the neighboring downstream plant operates with a larger size than the distant one.

*Keywords:* Vertically-linked industries; Location; Oligopoly; Transport Costs.

*JEL classification:* F12; L13; R12.

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## 1. Introduction

It is common sense (see MARKUSEN and VENABLES, 1999) that the success of Foreign Direct Investment (FDI) depends critically on the existence of input suppliers which are close enough to the subsidiary of the multinational firm. In order to get a full understanding of this, a deeper analysis of the operation of vertical linkages in space is necessary.

In this paper, with a two country setting, an imperfectly competitive upstream industry manufactures an intermediate good and sells it to a downstream industry. This industry processes it into a consumer good which is sold to final customers. Agglomeration follows from the interplay of the transport costs of intermediate and consumer goods.

The existing literature has shown this result assuming different specifications of market structure for both industries. VENABLES (1996) assumes that both industries are Dixit-Stiglitz monopolistic competitive. FUJITA and THISSE (2002, pp. 321-326) make the assumption that the upstream industry is Dixit-Stiglitz monopolistic competitive while the downstream industry operates under perfect competition. BELLEFLAMME and TOULEMONDE (2003) assume that both industries work under Cournot oligopoly.

This paper addresses the same issues of the previous literature with a different focus. First, there is an empirical evidence that a large share of consumer goods are non-tradable so that they must be offered in each location. The non-tradable character of consumer goods stems from the fact that production entails two successive vertically-related activities, namely manufacturing and distribution, the output of distribution being usually a non-tradable good. The paper keeps this aspect in its

assumptions. Second, the technology of firms, which is usually described as the sum of a fixed cost and a marginal production cost, is often more complex than this specification. In this paper, following PENG, THISSE and WANG (2006), we assume that the consumer good industry works under a technology described by a quadratic production function with decreasing returns to scale, substitution across inputs and a positive impact of input variety on output. Finally, another difference consists on the fact that both pecuniary externalities and technological externalities, through a localization economy, as in BELLEFLAMME, PICARD and THISSE (2000), are introduced.

The paper finds that the economy of localization and the intensity of the demand addressed to the upstream industry foster the clustering of the input suppliers while production and transport costs of the intermediate good lead to dispersion. Hence, as the growth of industry involves both an increase of the intensity of the demand and a decrease of costs, it determines a transition from a dispersion to the agglomeration of the upstream firms. If the input suppliers agglomerate, the neighboring downstream plant has a larger size than the distant one.

## 2. The model

### 2.1. Assumptions

A spatial economy is made by two countries (or regions):  $H(ome)$  and  $F(oreign)$ . Two upstream firms,  $U_1$  and  $U_2$ , supply differentiated inputs to firms producing an homogeneous consumer good under perfect competition. The downstream industry is made by symmetric firms, so that it can be represented by a perfectly competitive firm,  $D$ . This firm sets the parametric price 1 w.l.g.. The consumer

good is non-tradable, so that the firm  $D$  has two plants, each one being located in a different country. Hence firm  $D$  can be regarded as a multinational firm. Firms  $U_1$  and  $U_2$  have a unit constant production cost  $c$  if they locate in different countries and a unit cost  $c - \theta$  if they agglomerate, where  $\theta$  stands for a (Marshallian) localization economy. The intermediate good is shipped across the countries at a transport rate  $t$  and at a rate zero inside each country. The trade between an upstream plant in a country and a downstream plant in the same country is labelled a "local flow". The trade between units located in different countries is named a "cross flow". The locational patterns and flows are depicted in Figures 1 and 2.

(See Figures 1 and 2)

Firms  $U_1$  and  $U_2$  supply amounts of differentiated inputs  $x_1$  and  $x_2$  that are transformed by the downstream firm into an homogeneous consumer good according to the quadratic production function:

$$Y(x_1, x_2) = \alpha(x_1 + x_2) - \left(\frac{\beta}{2}\right)(x_1^2 + x_2^2) - \delta x_1 x_2 \quad (1)$$

where  $\alpha > 0, \beta > \delta \geq 0$ . The meaning of these conditions is the following.  $\alpha > 0$  stands for the intensity of final production in intermediate goods, i.e. the intensity of demand addressed to the upstream industry.  $\beta - \delta$  is a measure of sophistication of the downstream production process, i.e. an inverse measure of the degree of substitution between inputs.  $\delta > 0$  means that the inputs are substitutes instead of complements (see PENG, THISSE and WANG, 2006). It is assumed that the demand addressed to the upstream industry is high in relation to the unit

production cost of the input suppliers, so that we have  $\alpha - c > 0$ . Each upstream firm charges a fob mill price, so that its profit function is  $\pi_i = (p_i - c) q_i, i = 1, 2$ , where  $p_i$  stands for the mill price and  $q_i$  is total output.

The operation of the economy can be modelled by a three-stage game where:

**Stage 1:** Firms  $U_1$  and  $U_2$  select locations in  $H$  and  $F$ .

**Stage 2:** Firms  $U_1$  and  $U_2$  select prices  $p_1$  and  $p_2$ .

**Stage 3** Firms  $D$  determine demands for  $x_1, x_2$ .

The equilibrium is SGPE found through backward induction.

Given the mill prices of the inputs  $p_1$  and  $p_2$ , delivered prices  $p_1^d$  and  $p_2^d$  are formed (see Figures 1 and 2). Then the downstream firm determines the demands of the the inputs  $x_1$  and  $x_2$  by maximizing its profit function:

$$\pi_d = Y(x_1, x_2) - p_1^d x_1 - p_2^d x_2 \quad (2)$$

where  $Y(x_1, x_2)$  is given by (1). Maximizing  $\pi_d$  with relation to  $x_1$  and to  $x_2$ , we obtain the inverse demand functions for the inputs by the downstream firms:

$$p_i^d = \alpha - \beta x_i - \delta x_j, i, j = 1, 2, j \neq i \quad (3)$$

The direct demand functions for the inputs are:

$$x_i = a - bp_i^d + d(p_j^d - p_i^d), i, j = 1, 2, i \neq j \quad (4)$$

where

$$\begin{aligned} a &= \frac{\alpha}{\beta + \delta} \\ b &= \frac{1}{\beta + \delta} \\ d &= \frac{\delta}{\beta^2 - \delta^2} \end{aligned} \tag{5}$$

Given the symmetry of this framework, the input suppliers  $U_1$  and  $U_2$  charge identical mill prices  $p_1$  and  $p_2$  for the differentiated intermediate goods in each locational setting (dispersion or agglomeration).

Then, using input demand functions (4), it is easily seen that, in the dispersed locational setting of Figure 1, the downstream plants are equally sized and each plant uses more intensively the input that is supplied locally. By contrast, in the clustered pattern of Figure 2, both downstream plants use the inputs in the same proportion although the "distant" plant produces a smaller amount of output than the plant that lies close to the input suppliers.

## 2.2. Results

The results of the paper can be summarized in a proposition.

**Proposition 1** *Agglomeration of the input suppliers is an equilibrium iff*

$$\theta + 2\alpha \geq 2c + t$$

**Proof.** The first stage location game is a two person, doubly symmetric game where the payoff matrix of firm  $U_1$  is

		Firm $U_2$	
		$H$	$F$
Firm $U_1$	$H$	$\pi_A$	$\pi_S$
	$F$	$\pi_S$	$\pi_A$

where  $\pi_A$  stands for the profit of an upstream firm in an agglomeration and  $\pi_S$  represents the profit of an isolated input supplier. Then it is obvious that the outcome of this game depends on the sign of  $\pi_A - \pi_S$ . If the sign is positive, there are two symmetric location equilibria, where both upstream firms locate in the same country. If  $\pi_A - \pi_S$  is zero, each locational pattern is an equilibrium. If  $\pi_A - \pi_S < 0$ , the input suppliers will locate in different countries in equilibrium.

We deal first with case where firms  $U_1$  and  $U_2$  are geographically separated, depicted in Figure 1. We assume that all trade flows of inputs are positive. In the Appendix, necessary and sufficient conditions for this to happen are derived.



Then, the profit functions of the input suppliers are (see Figure 1)

$$\begin{aligned}\pi_{U_1} &= (p_1 - c) [x_1(p_1, p_2 + t) + x_1(p_1 + t, p_2)] \\ \pi_{U_2} &= (p_2 - c) [x_2(p_1 + t, p_2) + x_2(p_1, p_2 + t)]\end{aligned}\tag{6}$$

where  $x_1(\cdot)$  are direct demands for the inputs as given by (4). The Nash equilibrium prices associated with payoffs (6) are:

$$p_1^S = p_2^S = \frac{2a + 2bc + 2cd - bt}{4b + 2d}\tag{7}$$

Then we consider the profit functions for the case where the upstream firms agglomerate (see Figure 2). By using the demand functions for the inputs (4), profit functions become:

$$\begin{aligned}\pi_{U_1} &= (p_1 - (c - \theta)) [x_1(p_1, p_2) + x_1(p_1 + t, p_2 + t)] \\ \pi_{U_2} &= (p_2 - (c - \theta)) [x_2(p_1, p_2) + x_2(p_1 + t, p_2 + t)]\end{aligned}\tag{8}$$

The Nash equilibrium prices following from payoffs (8) are

$$p_1^A = p_2^A = \frac{2a + 2bc + 2cd - bt - 2b\theta - 2d\theta}{4b + 2d}\tag{9}$$

Equilibrium prices (9) hold only if the cross flows of the input are positive. We derive in the Appendix a necessary and a sufficient condition for this to be true.

Substituting prices (7) in the profit function (6) of the dispersed locational pattern, we obtain the payoffs of the location game:

$$\pi_1^S = \pi_2^S = \frac{(b+d)(2bc-2a+bt)^2}{2(2b+d)^2} \quad (10)$$

Performing the same operation for the agglomerated pattern, with prices (9) and profit function (8), we obtain:

$$\pi_1^A = \pi_2^A = \frac{(b+d)(2bc-2a+bt-2b\theta)^2}{2(2b+d)^2} \quad (11)$$

Comparing (10), and (11), we conclude that this location problem is non-trivial iff  $\theta > 0$ . If this condition is met, agglomeration is at least as profitable as locational separation iff :

$$\theta + 2\alpha \geq 2c + t \quad (12)$$

■

Clearly for a given value of the localization economy, agglomeration is fostered by the intensity of the demand addressed to the upstream industry and is stopped by the production and transport costs. As it brings about the increase of the demand and a decrease of costs, the evolution of the upstream industry causes a transition from dispersion to agglomeration of the input suppliers.

A corollary of Proposition 1 follows.

**Corollary 2** *A sufficient condition so that agglomeration of the upstream firms holds is that  $\theta \geq t$ .*

**Proof.** This follows directly from Proposition 1 and  $\alpha - c > 0$  by assumption. ■

### 3. Conclusions

This analysis has enabled us to conclude that agglomeration is fostered by the localization economy and the intensity of the demand addressed to the upstream industry and is prevented by the production and transport costs of the input. A sufficient condition for this to hold is that the localization economy outweighs the transport cost of the input.

Hence we can expect the evolution of the upstream industry to bring about a transition from dispersion to agglomeration as it entails usually an increase of the intensity of demand and a decrease of costs. Moreover the evolution of the upstream industry entails the arise of some kind of fragmentation of production since a downstream plant is supplied by an upstream firm located in a different country. This "distant" downstream plant produces a smaller amount of output than the plant that lies aside the input suppliers. Hence the size of a multinational firm subsidiary depends inversely on the distance to the clustered input suppliers.

This paper represents only a first step in the assessment of the location of two input suppliers to downstream firms working with a quadratic production function. A natural extension of the paper is to assume that there are many (or a continuum) of upstream firms. This extension is in line with the previous research by BELLEFLAMME, PICARD and THISSE (2000) and PENG, THISSE and WANG (2006).

#### **Appendix.**

It can be proved that there exists a situation with trade provided that the transport cost of the input is low enough. We need only to derive necessary and sufficient conditions for the cross flows to be positive.

If the upstream firms are dispersed, the condition that  $x_i(p_i + t, p_j) > 0, i, j = 1, 2, i \neq j$  (with prices 7) is equivalent to

$$t < \frac{2(a - bc)(b + d)}{6bd + 3b^2 + 2d^2} \quad (13)$$

On the other hand, if the input suppliers agglomerate, the cross flow  $x_i(p_i + t, p_j + t), i = 1, 2, i \neq j$  (with prices 9) is positive iff

$$t < \frac{2(a - bc + b\theta)(b + d)}{b(3b + 2d)} \quad (14)$$

If  $\theta = 0$ , the right hand side (r.h.s.) of (14) is larger than the r.h.s. of (13). As the former increases with  $\theta$  while the latter is a constant function of  $\theta$ ,

$$t < \frac{2(a - bc)(b + d)}{6bd + 3b^2 + 2d^2}$$

is a single sufficient condition for the existence of trade is both locational configurations. A necessary condition for this to hold is that  $\alpha - c > 0$ , that is met by assumption.

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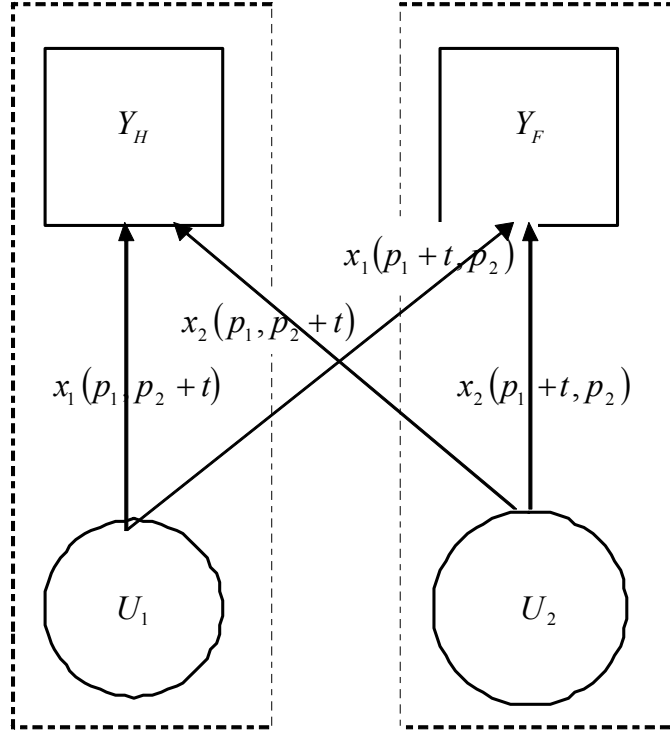


Figure 1: Separated locations

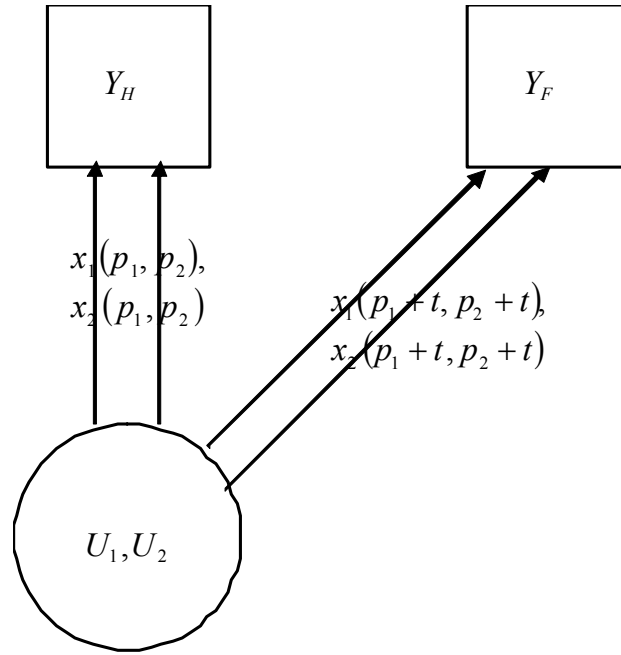


Figure 2: Agglomerated locations